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EFFECTS OF SURFACE TEXTURE AND SHAPE ON GRIT SELECTION BY HOUSE SPARROWS AND NORTHERN BOBWHITE

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Abstract.—We evaluated the influence of surface texture and shape on grit selection by House Sparrows (*Passer domesticus*) and Northern Bobwhite (*Colinus virginianus*). Captive birds were given a mixture of two grit types (angular/oblong and rounded/spherical) for seven or 14 days. At the end of this period, most birds (24 of 30 House Sparrows and 21 of 26 Northern Bobwhite) had more angular/oblong and less rounded/spherical grit ($P < 0.01$) in their gizzards than predicted on the basis of availability. An improved understanding of avian responses to surface texture, shape, and other grit characteristics may be useful in reformulating granular pesticides to reduce their attractiveness to birds. *Received 20 Jan. 1994, accepted 4 April 1994.*

Granular pesticides are used extensively for insect control and many are acutely toxic to birds (e.g., Balcomb et al. 1984, Hill and Camardese 1984). One potential route of avian exposure to granular pesticides involves birds' intentional consumption of granules as a source of grit. A better understanding of factors influencing grit preferences may suggest ways to alter granular formulations to reduce their attractiveness to birds and lower the probability that granules will be consumed by birds.

Few data are available on the process of grit selection by birds (e.g., Sadler 1961). Grit choice is probably influenced by physical characteristics of grit particles such as size, color, surface texture, and shape. We evaluated the influence of surface texture and shape on grit selection by House Sparrows (*Passer domesticus*) and Northern Bobwhite (*Colinus virginianus*). These species were chosen for experiments because they are ground-foraging granivores and omnivores, respectively (De Graaf et al. 1985), and thus they represent the feeding guilds of birds most likely to be exposed to granular pesticides. The House Sparrow also was chosen because it uses a large amount of grit compared with other birds (Keil 1973; Gionfriddo and Best, in press).

METHODS

Free-ranging House Sparrows were captured with mist nets at several rural sites in Story County, Iowa. They were fitted with numbered leg bands, transferred to an outdoor aviary, and given at least eight days to acclimate to captivity. Gizzards of House Sparrows then were voided by saline flushing. Each bird was anesthetized by injecting the pectoral muscle with 0.15 cc of ketamine hydrochloride (Vetalar, diluted to 10 mg/ml) to which about 0.005

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FIG. 1. Angular/oblong and rounded/spherical grit used in experiments with House Sparrows (left) and Northern Bobwhite (right).

cc of diazepam (Valium, 5 mg/ml) had been added. We then flushed the gizzard with 30 cc of saline solution (0.9% sodium chloride irrigation, USP) delivered in 20 1.5-cc injections. We used a 10-ml Cornwall syringe pipet with a ball-tipped, straight intubation needle (18 gauge, 7.6 cm long). The needle was long enough to reach a House Sparrow's gizzard when inserted through the mouth. Gizzard contents were hydraulically flushed through the esophagus and mouth while the bird was held in a vertical position, tail up and beak down. This procedure effectively removes all or nearly all food and grit from the gizzards of most House Sparrows, and the recovery rate of the birds is high (92%) (Gionfriddo et al., in press). After recovery from anesthesia, 30 birds were placed in an aviary compartment with food and water. The experiment began when grit was added at dawn the next day.

Juvenile (11-week-old) Northern Bobwhite purchased from a commercial game bird producer were transferred to aviaries where they were held for 18 weeks before being used in the experiment. There was no need to void gizzards of the Northern Bobwhite because grit had been withheld from these birds since hatching.

During acclimation and experiments, House Sparrows and Northern Bobwhite were housed in outdoor aviary compartments measuring 3.7 × 4.6 × 2.1 m and maintained on a commercially prepared wild bird seed mixture (Cardinal Brand Wild Bird Feed, Des Moines Feed Co., Des Moines, Iowa) containing millet, milo, cracked corn, sunflower seeds, peanuts, and wheat. Birds also were provided with vitamin-enriched water. Grit was provided only during experiments.

Two types of grit were used, representing two extremes in surface texture/shape. For House Sparrows, rounded/spherical grit consisted of "blanks" of silica (quartz) granules used for the pesticide FURADAN 15G, and angular/oblong grit was hammermilled "Col-

orado quartz" (Fig. 1). (Best and Gionfriddo [1991] described the system used to characterize grit surface texture/shape; surface textures ranged from well-rounded to angular and shapes from spherical to oblong.) For Northern Bobwhite, clear glass beads were used as rounded/spherical grit and angular/oblong grit was hammermilled clear glass. For both species, the two grit types were identical in mineral composition (quartz or glass), color (clear), and size (both grit types were sieved to a size range of 0.4–0.8 mm for House Sparrows and 1.8–2.4 mm for Northern Bobwhite, respectively; these sizes represent the middle of the normal ranges of grit sizes used by free-ranging birds of these two species [Best and Gionfriddo 1991]). All grit was tumbled in a vibrating tumbler for five days to produce a "frosted" surface similar to that of the silica granules and to dull the jagged edges of the hammermilled grit.

Grit was provided to birds during each experiment in two square grit trays, each measuring 0.5 m^2. Sides of the trays were constructed of 5 × 10 cm lumber, and bottoms consisted of the cement aviary floor. Each tray contained a mixture of equal amounts (by volume) of angular/oblong and rounded/spherical grit. Volumetric measures of grit were used because the large amounts of grit needed in the experiments precluded our counting individual particles provided to birds and necessitated the use of an alternative measure. Each tray was supplied with 10 cc (House Sparrows) or 25 cc (Northern Bobwhite) of grit, which was replaced every two days. Later, we counted the particles in equal volumes of angular/oblong and rounded/spherical grit to determine the proportions of the two grit types in the grit mixtures given to Northern Bobwhite and House Sparrows. Ratios of angular/oblong to rounded/spherical grit were 53:47 for Northern Bobwhite and 35:65 for House Sparrows. These ratios were then used in deriving expected values for Chi-square analysis.

In the House Sparrow experiment, all (30) birds were sacrificed after 14 days; in the Northern Bobwhite experiment, half of the 26 birds were sacrificed after seven days and half after 14 days. Gizzards were removed and preserved in 95% ethanol. Later, each gizzard was sliced in half with a razor blade, and the contents were flushed into a Petri dish and examined carefully under a zoom, stereo microscope. Grit particles were separated from other gizzard contents. Gizzard contents were searched thoroughly at least two times. Grit particles of the two types were then sorted and counted.

RESULTS

All House Sparrows readily consumed the grit provided. The mean grit count per bird was 139.5 (±82.5 [SD]), well within the range of values for free-ranging House Sparrows (Gionfriddo and Best, in press). Twenty-four of 30 birds had greater proportions of angular/oblong grit in their gizzards than if they had consumed grit randomly (Chi-square analysis, $P < 0.01$); three had significantly more rounded/spherical grit (Fig. 2). Only three birds had no apparent grit surface texture/shape preference. Ratios of angular/oblong to rounded/spherical particles in their gizzards did not differ from 35:65.

Gizzard contents of Northern Bobwhite given grit for seven days were similar to those of 14-day birds. All birds in both groups consumed grit, and mean grit counts per bird did not differ between groups ($t = 0.12$, df = 23, $P = 0.91$; 7-day birds: $\bar{x} = 145.5 \pm 81.6$, 14-day birds: $\bar{x} = 148.9 \pm 68.8$). Furthermore, the proportion of the grit particles that were angular/oblong did not differ between gizzards of the two groups of birds

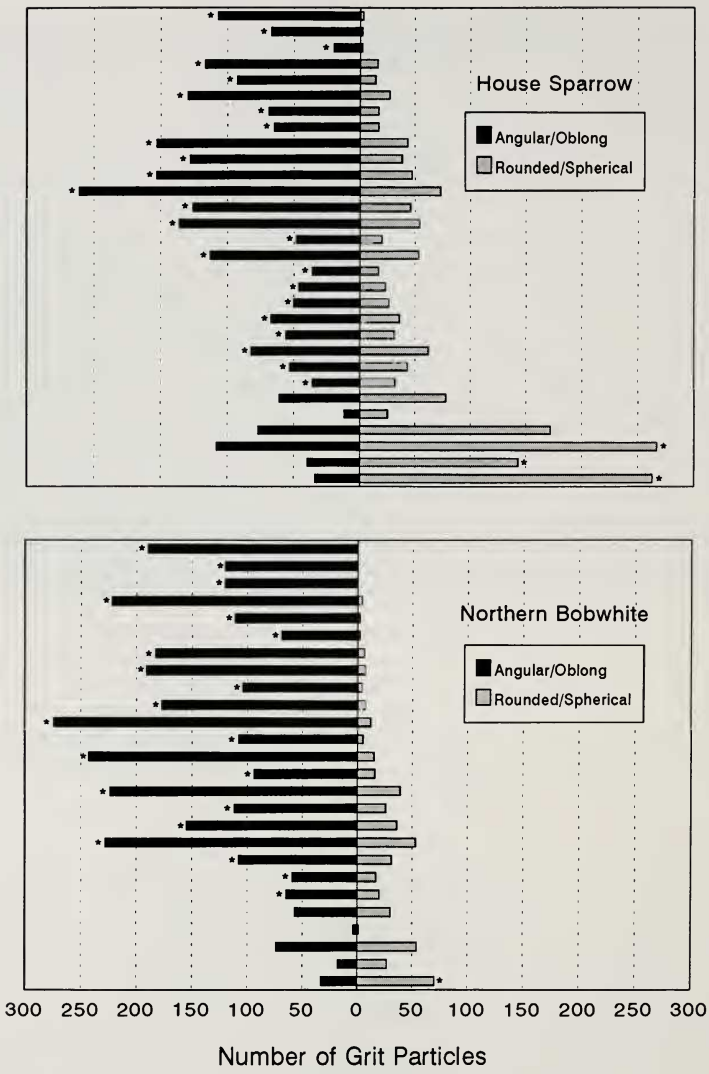

FIG. 2. Angular/oblong and rounded/spherical grit particles in gizzards of House Sparrows and Northern Bobwhite given a mixture of the two types of particles. Asterisks denote birds that consumed one grit particle type in proportions greater than expected on the basis of its availability (Chi-square analysis, $P < 0.01$).

($t = 1.68$, df = 19, $P = 0.11$). Consequently, the 7-day and 14-day data sets were combined. Twenty-one of 26 gizzards contained greater proportions of angular/oblong than rounded/spherical grit, and one gizzard contained more rounded/spherical grit (Chi-square analysis, $P < 0.01$). Proportions of the two grit types in the remaining four gizzards did not differ significantly.

DISCUSSION

House Sparrows and Northern Bobwhite used in our experiments differed in several ways. The House Sparrows formerly were free-ranging birds experienced in using grit, whereas the Northern Bobwhite were captive-raised juveniles never exposed to grit. The two species also are very different in body size and represent different avian orders. Despite these differences, the responses of House Sparrows and Northern Bobwhite were very similar in our experiments. Both species clearly expressed a preference for angular/oblong rather than rounded/spherical grit when given a mixture of the two types. The occurrence of this preference in birds with prior experience in grit use and in birds with no prior exposure to grit suggests the preference may have a genetic basis.

Grit preferences may be related to diet. The amounts, sizes, and shapes of grit used by birds vary with diet (e.g., Norris et al. 1975, Alonso 1985, Norman and Brown 1985, Hogstad 1988). Perhaps certain grit surface textures/shapes increase the efficiency of digestion of some foods more effectively than others. Based on examination of grit, Smith and Rastall (1911) suggested that Red Grouse (*Lagopus l. scoticus*) needed "subangular and roughly rounded" small pebbles to grind foliage of *Calluna* and that grit with cutting edges and sharp points was unsuitable. The House Sparrows and Northern Bobwhite may have selected angular/oblong grit because it more efficiently ground the seeds they ate. The degree to which diet influences grit selection has not been tested formally.

Grit present in a bird's gizzard depends not only upon selection of particles for consumption, but also upon the dynamics of retention in the gizzard. Grit selection, as we have measured it here, thus includes a component of grit retention. Particle characteristics such as surface texture and shape may influence retention of grit. We conducted other experiments with captive House Sparrows to evaluate the relative contribution of grit-retention processes to the surface texture/shape of grit present in gizzards (Best and Gionfriddo, unpubl. data). Birds were administered (oral gavage) or fed (mixed with canned dog food) equal amounts of the angular/oblong and rounded/spherical grit for a period of time, deprived of grit for two days, and then sacrificed. In both experiments, the proportions of the two grit types did not differ (Chi-square analysis, $P >$

0.5) in most gizzards. The results of these retention experiments suggest that surface texture/shape may not influence grit retention. We conclude that the grit-use patterns observed in gizzards of experimental House Sparrows and Northern Bobwhite reflect differential selection (rather than differential retention) of angular/oblong and rounded/spherical particles.

Although grit selection may be the primary factor determining the grit in birds' gizzards, it can be constrained by availability of grit of various types. Grit selection also may be affected by diet, characteristics of grit already in the gizzard, and other factors. More experimental work is needed, with additional avian species, before we will have a clear understanding of avian grit preferences and of the influences of grit characteristics such as surface texture/shape on grit choice and retention in birds. Such knowledge may be useful in "designing" granular pesticides to make them less attractive to birds.

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22nd International Ornithological Congress

The 22nd International Ornithological Congress will be held in Durban, South Africa from 16–22 August 1998. Professor Peter Berthold (Germany) will serve as President, Dr. Janet Kear (United Kingdom) as Vice President and Dr. Aldo Berruti as Secretary-General. This Congress will include a full scientific program and a large series of ornithological tours to numerous areas within southern Africa. All interested ornithologists are invited to take part.

Potential members of the Durban congress are requested to contact Dr. Aldo Berruti (Durban Natural Science Museum, PO Box 4085, Durban 4000, South Africa) to be placed on the mailing list, or to provide suggestions on any aspects of the 22nd congress. Persons on the mailing list will be sent information on all aspects of the congress in proper time.

The chairman of the Scientific Program Committee is Dr. Lukas Jenni (Schweizerische Voegelwarte, CH-6204 Sempach, Switzerland). Suggestions for the scientific program should be sent to him. Announcements for the scientific program will be published separately. Letters of inquiry about the scientific program can be sent to Dr. Lukas Jenni, Professor Peter Berthold, Professor Walter Bock (Secretary of the IOC, Box 37 Schermerhorn Hall, Dept. of Biological Scienes, Columbia Univ., New York, New York 10027, USA).